Communications Issues for Virtual Presence in the Solar System

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Background

- Motivation for this Paper:
  - The symposium has provided an interesting look on "Frontiers in Deep Space Communications and Navigation". The excitement of being at the frontier and sharing the frontier culture with those staying behind has been the engine for human desire for exploration of Earth and Space. Virtual presence in the solar system should provide the cutting edge for the human experience of going to the frontiers of the solar system

  - The Communications Systems and Research Section at JPL through sponsorship of TMOT and TAP has a partnership agreement with the Integrated Media Systems Center at the University of Southern California; JPL is a NASA Center of Excellence for Deep Space Communications while the latter is the NSF (National Science Foundation) Center of Excellence for Integrated Media Systems so it was just a mater of time before the two authors got interested in exploring the synergies of the two disciplines and put this paper together on Communications Issues for Virtual Presence in the Solar System

  - First a multimedia model is developed for virtual presence in the Solar system; then the communications issues for this multimedia model are examined.

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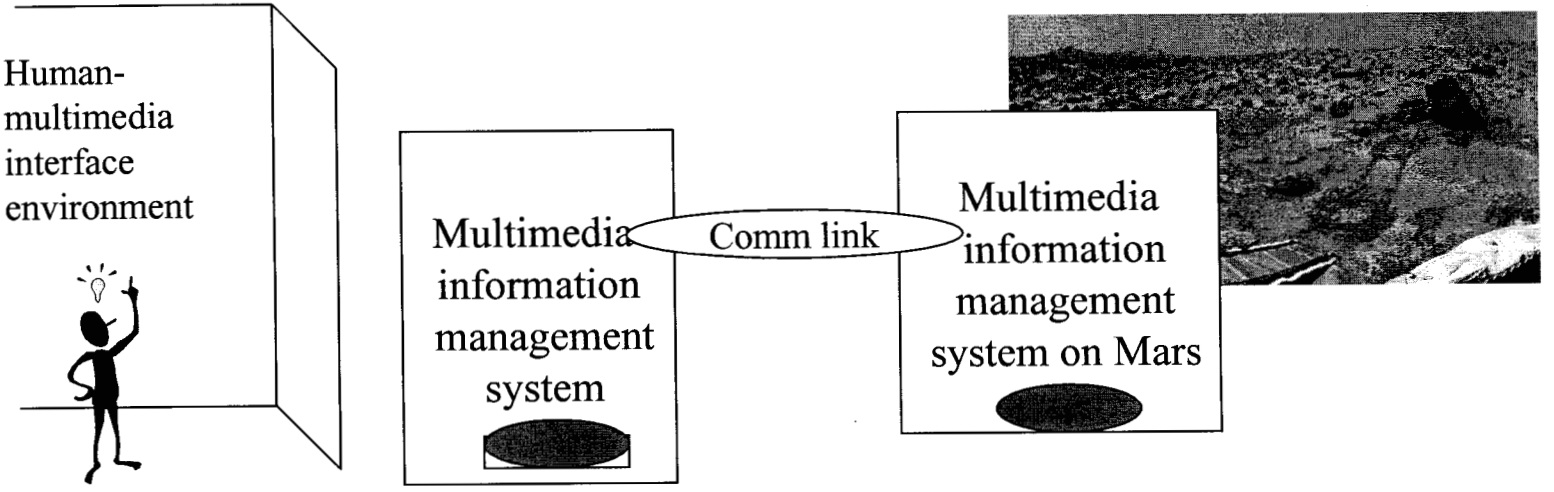
A Multimedia Model for Virtual Presence on Mars

- First, we consider a Multimedia Model for Virtual Presence on Mars consisting of:
  - Sensors and robots at or around Mars with autonomy and smarts
  - Human-multimedia interfaces including interactive audio and video video, display or animation of scientific data, environment simulators to give the human sense of tactile interaction with remote objects, sense of acceleration, balance, temperature, pressure, etc.
  - An information management system including information storage and retrieval, association of information, abstraction of information and its reverse "rendering", simulation, analysis
  - An internet-type communication system to integrate the above three elements

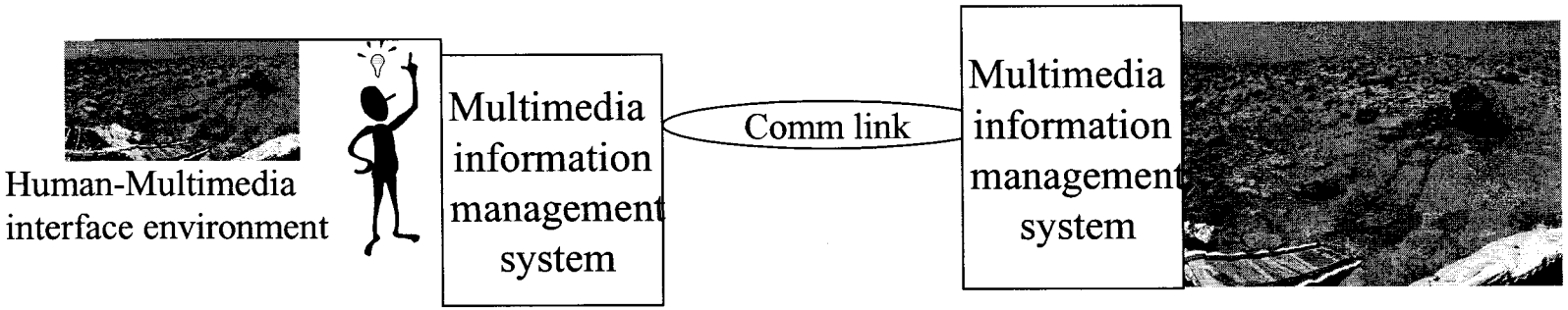


Multimedia Model for Virtual Presence on Mars, continued

- Latency and bandwidth limitations of the communications system will always be a major issue for virtual presence in the solar system; interestingly our colleagues at USC have also been concerned with the implications of bandwidth and latency constraints of the internet on integrated multimedia systems; some of the same strategies seem promising to mitigate the effects of the significantly more difficult latency and bandwidth constraints of deep space communications links on virtual presence in the Solar System
  - Data compression is always a powerful tool for data reduction to mitigate bandwidth requirements
    - Modeling and abstraction can be used extensively at the information source to record changes at the remote site at reduced data rates; modeling and "rendering" is used at the point of human interaction to render the abstract information back into a real life format
  - Intelligence at the remote site and closed loop simulation at the point of human interaction can mitigate the latency problems- let us look at this scenario for virtual presence on Mars

A Multimedia Model for Virtual Presence on Mars, continued

- To get a feel for an hour of operations and experience with the multimedia system for virtual presence on Mars let us assume that Jane, a JPL scientist, wants to dispatch a robot already on Mars to the rock Yogi and then use the robot arm to tip the rock over to analyze the chemical composition of its underside:
  - From the Mars Multimedia portal at JPL, Jane will initiate a dry run simulation of the event by giving a voice command: "Mars rover # 1 go to Yogi!"
  - The multimedia information management system will run a simulation of the ride to Yogi based on information already in the information management system
  - Jane will try to maneuver the simulated robot arm and tip over the simulated rock; she may have to try several approaches before success
  - Once satisfied about the simulation, Jane may request execution of the request by the project who may send the request to the rover for execution
  - The rover would try to execute the request; it may be successful or it may abort the request if it finds out that the rock is frozen to ground and cannot be safely tipped over; the information data base is updated and Jane is notified.



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Conclusions and Recommendations

- Virtual presence in the Solar System is modeled as a multimedia system with four basic components:
  - Sensors and robots with autonomy and smarts distributed in the Solar System
  - Human-multimedia interface environment
  - Multimedia information management system with nodes on Earth and in the Solar System:
  - An Internet like communications system to integrate the above 3 elements
- The multimedia system for virtual presence in the Solar System has to and can live with the basic latency due to light travel time
  - Intelligence at the remote site and closed-loop simulation at the point of human interaction are used to mitigate the latency problems-
  - It can live with additional delays inherent in Deep Space Mission Services but such delays should be kept to a minimum to reduce operations cycle time
- Planned bandwidths for the Mars network should be able to support the multimedia system for virtual presence on Mars
  - Data compression by modeling and abstraction is a powerful tool for data reduction.

Acknowledgements

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